CLAIMS

1. A system for determining the three dimensional shape of an object,

being a system having a first measuring means for measuring a first distance and direction from a fixed first observation point to a first group of measurement points on an object,

and a second measuring means for measuring a second distance and direction from a movable second observation point to a second group of measurement points on the aforementioned object,

at least one point among said second group of measurement points being the same measurement point as at least one point among the aforementioned first group of measurement points, and said second group of measurement points including at least one measurement point not included in the aforementioned first group of measurement points,

and further being provided with a calculating means for calculating the traveling velocity vector of the second observation point from the measurement results concerning the aforementioned same measurement point due to the first and second measuring means, correcting the aforementioned second measurement results based upon said traveling velocity vector, and calculating the three dimensional coordinates of the measurement points of the first group and the second group,

and a displaying means that displays an image of the object based upon the aforementioned three dimensional coordinates.

2. A system as described in claim 1, characterized in that the aforementioned second measuring means is provided with a scanner unit comprising a laser radar unit for ranging each point, a four-faceted polygon mirror for performing horizontal scanning, and a planar swing mirror for performing vertical scanning.

3. A system as described in claim 1 or claim 2, characterized in that the aforementioned second measuring means is provided with a controller unit which internally houses a radar unit control portion, control portions for two mirrors, and an interface portion for sending measurement results to a measuring computer.

4. A system as described in any of claims 1 through 3, characterized in that the aforementioned second measuring means is provided with a computer provided with a recording medium and which can store measurement results on said recording medium, and can control the aforementioned scanner unit and controller unit.

5. A system as described in any of claims 1 through 4, wherein the velocity vector for which the three dimensional coordinate error is minimized is determined by the conjugate gradient method, with the assumption that the traveling velocity vector of the aforementioned second observation point is time-independent, using the measurement results concerning the aforementioned same measurement point due to the first and second measuring means,

and the measurement result from the second observation point is corrected using said velocity vector.

6. A system as described in claim 5, characterized in that the translational motion vector that minimizes the following equation is determined by the conjugate gradient method.

[Equation 1]

$$E(\mathbf{p}) = \frac{1}{N(M-1)} \sum_{i}^{N} \sum_{j}^{M} \rho(z_{ij}(\mathbf{p}))$$

where

$$\mathbf{p} = (\mathbf{m}, \mathbf{q})$$

$$z_{ij}(\mathbf{p}) = \left\| \mathbf{R}(\mathbf{q}) \mathbf{g}(v) i + \mathbf{m} - \mathbf{y}_{ij} \right\|^2$$

$$\rho(z_{ij}(\mathbf{p})) = \log(1 + \frac{1}{2} z_{ij}(\mathbf{p})^2)$$

N: number of points of measured data

M: number of measured data

Here,

$E(\mathbf{p})$ is an error function defined as the weighted average of the $\rho(z_{ij}(\mathrm{p}))$'s using the M estimation method with a Lorentzian function.

$z_{ij}(\mathbf{p}) = |\mathbf{R}(\mathbf{q})\, g(v)_i + m - y_{ij}|^2$

is the distance between corresponding points in the measurement results of the first and the second measuring means.

m is the translational motion vector.

y_{ij} is the corresponding point in the *j*th measured image.

p is a parameter group comprising the translational motion vector **m** and a quaternion **q** that represents rotation.

R(**q**) is a function of the quaternion q that represents rotation.

g(v)i is a parameter for shape distortion due to uniform velocity motion.

7. A system as described in claim 6, characterized in that a measurement point from the aforementioned second group that is not included in the aforementioned first group of measurement points is corrected by using m', where said m' is the $\mathbf{R}(\mathbf{q})\, g(v)_i + m$ that minimizes $z_{ij}(\mathbf{p})$.

8. A system as described in any of claims 5 through 7, wherein the aforementioned velocity vector includes a rotational component and a horizontal motion component.

9. A method for determining the three dimensional shape of an object,

having a procedure for measuring a first distance and direction from a fixed first observation point to a first group of measurement points on an object,

and a procedure for measuring a second distance and direction from a movable second observation point to a second group of observation points on the aforementioned object,

at least one point among said second group of measurement points being the same measurement point as at least one point among the aforementioned first group of measurement points, and said second group of measurement points including at least

one measurement point not included in the aforementioned first group of measurement points,

and further having a procedure for calculating the traveling velocity vector of the second observation point from the measurement results concerning the aforementioned same measurement point due to the first and second measuring means,

and a procedure for calculating the three dimensional coordinate of said first group and second group of observation points, by correcting the aforementioned second measurement result based upon said traveling velocity vector.

10. A method as described in claim 9, where the aforementioned procedure for measuring a second distance and direction is carried out with a scanner unit comprising a laser radar unit for performing ranging of each point, a four-faceted polygon mirror for performing horizontal scanning, and a planar swing mirror for performing vertical scanning.

11. A method as described in claim 9 or 10, where the aforementioned procedure for measuring a second distance and direction includes a procedure for sending measurement results to a measurement computer provided with a recording medium, through an interface.

12. A method as described in any of claims 9 through 11, where the aforementioned procedure for measuring a second distance and direction includes a procedure for saving measurement results to a recording medium, and a procedure for controlling a scanner unit and control unit with a computer.

13. A method as described in any of claims 9 through 12, wherein the velocity vector for which the three dimensional coordinate error is minimized is determined by the conjugate gradient method, with the assumption that the traveling velocity vector of the aforementioned second observation point is time-independent, using the measurement results concerning the aforementioned same measurement point due to the first and second measuring means,

and the measurement result from the second observation point is corrected using said velocity vector.

14. A method as described in claim 13, characterized in that the translational motion vector that minimizes the following equation is determined by the conjugate gradient method.

[Equation 2]

$$E(\mathbf{p}) = \frac{1}{N(M-1)} \sum_{i}^{N} \sum_{j}^{M} \rho(z_{ij}(\mathbf{p}))$$

where

$$\mathbf{p} = (\mathbf{m}, \mathbf{q})$$

$$z_{ij}(\mathbf{p}) = \left\| \mathbf{R}(\mathbf{q}) g(v)_i + m - \mathbf{y}_{ij} \right\|^2$$

$$\rho(z_{ij}(\mathbf{p})) = \log(1 + \frac{1}{2} z_{ij}(\mathbf{p})^2)$$

N: number of points of measured data

M: number of measured data

Here,

$E(\mathbf{p})$ is an error function defined as the weighted average of the $\rho(z_{ij}(p))$'s using the M estimation method with a Lorentzian function.

$z_{ij}(\mathbf{p}) = |\mathbf{R}(\mathbf{q})\, g(v)_i + m - y_{ij}|^2$ is the distance between corresponding points in the measurement results of the first and the second measuring means.

m is the translational motion vector.

y_{ij} is the corresponding point in the jth measured image.

p is a parameter group comprising the translational motion vector **m** and a quaternion **q** that represents rotation.

R(**q**) is a function of the quaternion q that represents rotation.

g(v)i is a parameter for shape distortion due to uniform velocity motion.

15. A method as described in claim 14, characterized in that a measurement point from the aforementioned second group that is not included in the aforementioned first group of measurement points is corrected by using m', where said m' is the $\mathbf{R}(\mathbf{q})\ g(v)_i + m$ that minimizes $z_{ij}(\mathbf{p})$.

16. A method as described in any of claims 13 through 15, wherein the aforementioned velocity vector includes a rotational component and a horizontal motion component.